Is mid-latitude convection activating chlorine in the lower Stratosphere?

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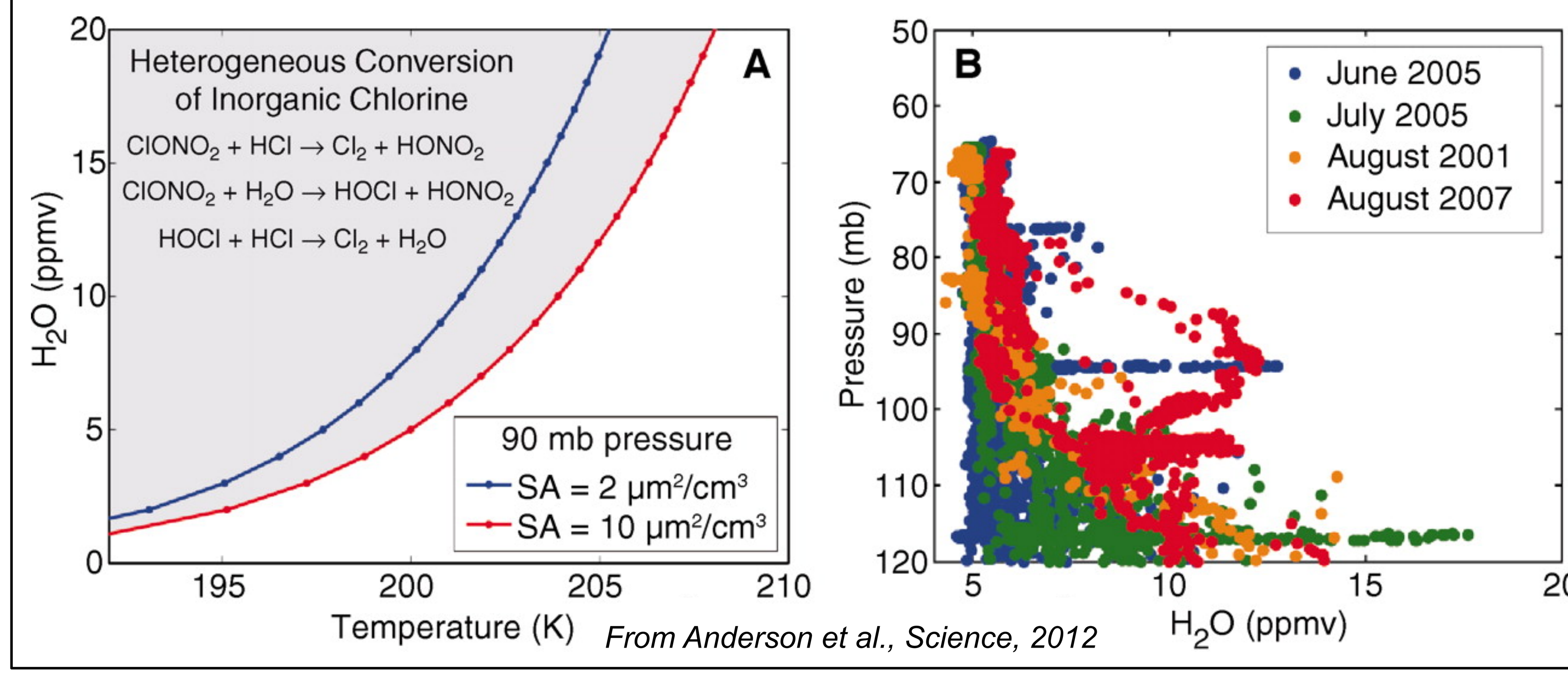
1. Introduction:

Anderson et al. (2012) argued that injection of water vapor by deep convection into the mid-latitude lower stratosphere would activate chlorine and destroy ozone.

To test this provocative idea, we explored the ClO measurements made by the Aura Microwave Limb Sounder (MLS), to see if it shows activated chlorine in regions impacted by deep convection. We find it does not, which casts doubt on the importance of Anderson's hypothesis.

2. Anderson's Hypothesis:



From Anderson et al., Science, 2012

1. Threshold conditions under which chlorine is rapidly activated (i.e., converted from reservoir species HCl and $ClONO_2$ to ozone-destroying ClO) is a strong function of both H_2O and temperature (left panel, A).
2. Summertime deep convection injects water vapor into the mid-latitude lower stratosphere (panel B, also Dessler et al., 2004, 2009; Mullendore et al. 2005), allowing the atmosphere to access regions where activation of chlorine is rapid
3. With higher ClO and strong sunlight conditions, O_3 may be rapidly lost.

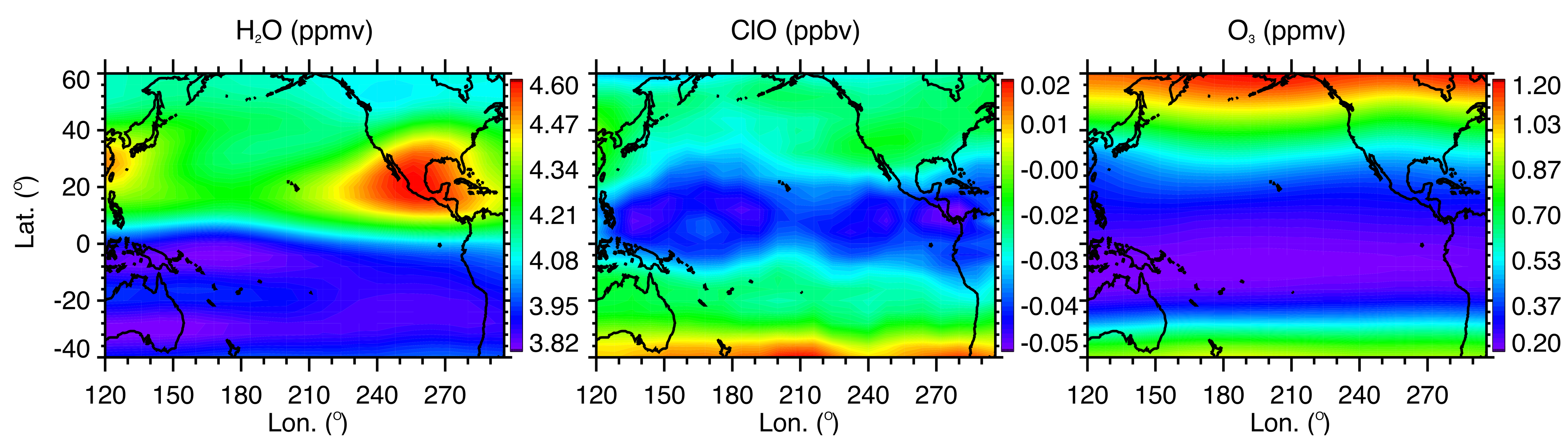
3. Datasets:

To test Anderson's idea, we turn to stratospheric ClO measurements from MLS. We use v3.3 Level 2 products from August 2004 to December 2011. Due to the strong diurnal variations of ClO we only examine valid ClO measurements during daytime.

We also use water vapor (H_2O) and ice water content (IWC) measurements from MLS v3.3 products. The IWC is used in our study to remove ClO measurements that are contaminated by ice-induced artifacts.

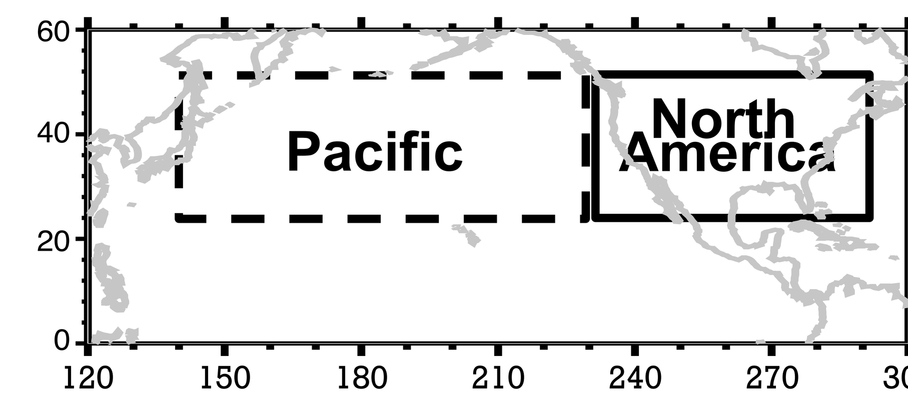
4. Analysis:

1. Summertime distributions of MLS H_2O, ClO, and O_3 in lower stratosphere (68-100 hPa)



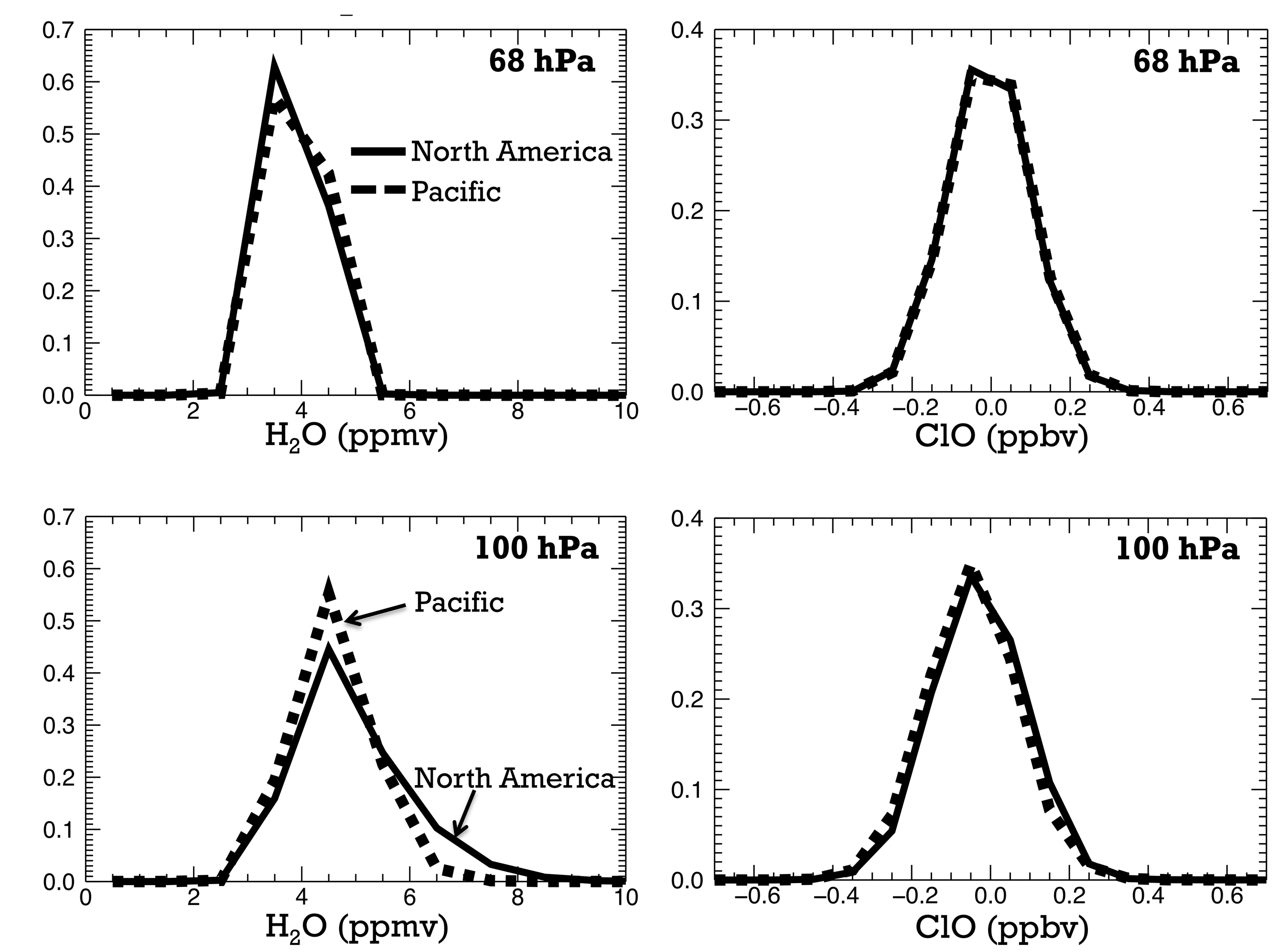
- Clear enhancement of H_2O over summertime North America
- Barely see elevated ClO, therefore, the direct effect on O_3 might be potentially unimportant
- Convective detrainments contain high H_2O and low O_3, therefore we see lower concentration of O_3 in North America, but not necessarily due to ClO destruction

2. North America and Pacific Regional Summer Comparisons



NA: H_2O & ClO will be "perturbed" by frequent deep convective penetration

PC: "unperturbed" region.



- H_2O almost identical over both regions at 68 hPa
- Enhanced H_2O over NA at 100 hPa, but not for ClO.
- ClO over NA and PC track with each other, no major differences.

5. Summary:

Our analysis shows that even though the enhanced H_2O is evident over North America ("perturbed" by frequent deep convective detrainments) in summertime, we did not see the corresponding enhancement of ClO. This casts some doubt on the idea that deep convection penetrating into lower stratosphere is leading to rapid ozone loss in our present atmosphere. In the future, we intend to explore trace gas measurements such as CO and HCl to see if we could find more evidences.

Reference:

- Anderson J. G., et al. (2012), Science 337, 835-839.
- Dessler, A. E., and S. C. Sherwood (2004), J. Geophys. Res., 109.
- Dessler, A. E. (2009), J. Geophys. Res., 114.
- Mullendore, G. L., et al. (2005) , J. Geophys. Res., 110, D06113.
- Ravishankara,A. R. (2012), Science, 337, 809-810.